Table 2: Summary of ACn Command and Response Functionality

Commands:

P	LSDU	Function
0	null	Resynchronisation
0	non-null	Transmitting data
1	null	Requesting data
1	non-null	Exchanging data

Responses:

F	LSDU	Function
0	null	Acknowledgement of resynchronisation or acknowledgement of received data
0	non-null	(Not allowed)
1	null	Acknowledgement, requested data unavailable
1	non-null	Acknowledgement with requested data

7.4.3.3 Type 3 Operation Response Information Field

Every ACn response PDU shall contain a status subfield in its information field. The remainder of the information field may be either null or non-null, and if non-null shall contain a link service data unit as shown in figure 23.

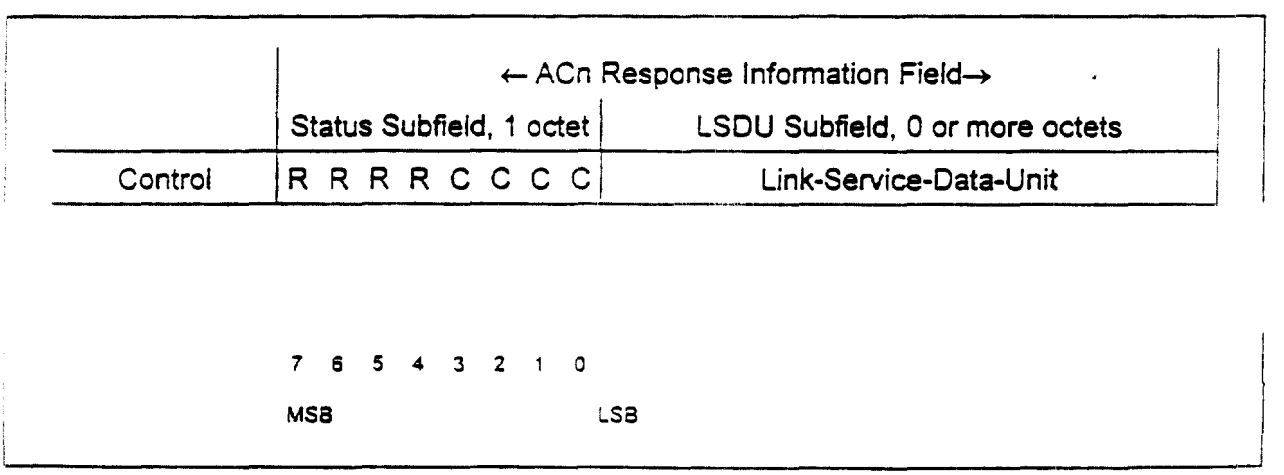


Figure 23: ACn Response Information Field Format

The code returned in the CCCC part of the status subfield indicates the success or failure of information passage in the command PDU (from the initiating LLC to the responding LLC). The possible values of CCCC are given in table 3

Table 3: ACn Response Status Subfield CCCC Values

C	C	C	C	MNEMONIC	CATEGORY	DESCRIPTION
0	0	0	0	OK	Success	Command accepted
0	0	0	1	RS	Perm Err	Unimplemented or inactivated service
0	1	0	1	UE	Perm Err	LLC user interface error
0	1	1	0	PE	Perm Err	Protocol error
0	1	1	1	IP	Perm Err	Permanent implementation dependent error
1	0	0	1	UN	Temp Err	Resources temporarily unavailable
1	1	1	1	IT	Temp Err	Temporary implementation dependent error

↑

First CCCC subfield bit delivered to / received from the MAC sublayer

All other CCCC codes are reserved

The code returned in the RRRR part of the status subfield indicates the success or failure of information passage in the response PDU (from the responding LLC to the initiating LLC). The possible values of RRRR are given in table 4.

Table 4: ACn Response Status Subfield RRRR Values

R	R	R	R	MNEMONIC	CATEGORY	DESCRIPTION
0	0	0	0	OK	Success	Response LSDU present
0	0	0	1	RS	Perm Err	Unimplemented or inactivated service
0	0	1	1	NE	Perm Err	Response LSDU never submitted
0	1	0	0	NR	Success	Response LSDU not requested
0	1	0	1	UE	Perm Err	LLC user interface error
0	1	1	1	IP	Perm Err	Permanent implementation dependent error
1	0	0	1	UN	Temp Err	Resources temporarily unavailable
1	1	1	1	IT	Temp Err	Temporary implementation dependent error

↑

First RRRR subfield bit delivered to / received from the MAC sublayer

All other RRRR codes are reserved

In a response PDU with the final bit set to 0, the RRRR subfield shall be set to "NR".

7.5 LLC Description of the Procedures

7.5.1 Procedure for Addressing

The address field of the frame shall be used to indicate the link address of the LPDU.

7.5.1.1 Type 1 Procedure

Private link addressing shall be supported by the Mobile Equipment on the uplink and by the Fixed Equipment in the downlink. Private, multicast and broadcast addressing shall be supported in the downlink.

7.5.1.2 Type 3 Procedure

The link address shall be private.

A Mobile Equipment shall be able to handle one pair of transmitting and receiving access points with private link address.

A Fixed Equipment shall be able to handle one pair of transmitting and receiving access points with private link address, for each Mobile Equipment in the communication zone at one time.

7.5.2 Procedure for the Use of the P/F Bit

7.5.2.1 Type 1 Procedure

An UI command PDU shall only be transmitted with the P bit set to *0*.

7.5.2.2 Type 3 Procedure

LLC shall set the P bit in an ACn command PDU to *0* if the command PDU is not a request for the remote LLC to return an LSDU in its acknowledgement. Thus the P bit is set to *0* when data is to be passed only from the transmitting station to the receiving station, or when the command PDU is to be passed only for resynchronisation.

LLC shall set the P bit in an ACn command PDU to *1* if the command PDU is a request for the remote LLC to return an LSDU in its acknowledgement. Setting the P bit to *1* allows data to be passed in both directions. However, if it is desired that data pass only from the responding LLC to the transmitting LLC, a null information field may be placed in the command PDU.

When transmitting an ACn response PDU, LLC sets the F bit equal to the P bit in the received ACn command PDU and includes a non-null LSDU subfield only if the F bit is a *1*.

7.5.3 Procedures for Link Set-Up

The transmit sequence state variable V(SI), receive state variable V(RI) and reception state variable V(RB) shall be created and deleted together with the creation and deletion of the corresponding SAP.

The transmit sequence state variable V(SI) shall be created with a value of *0*.

NOTE: No sequence number resynchronisation is defined since it is assumed that the state variables are not deleted (e.g. by power down, reset) in one communication zone.

7.5.4 Procedures for Information Transfer

7.5.4.1 Type 1 Procedure

Information transfer shall be accomplished by transmitting the UI command PDU with the P bit set to *0*.

The C/R bit in the MAC control field shall be used to identify that a command is contained in the PDU.

Reception of the UI command PDU shall not be acknowledged by the logical data link procedures.

NOTE: Since the reception of an UI command PDU is not be acknowledged by the logical data link procedures, the UI PDU may be lost if a logical data link exception occurs during the transmitting of the command PDU

7.5.4.2 Type 3 Procedures

7.5.4.2.1 Transmitting ACN Commands

Information transfer from an initiating LLC to a responding LLC shall be accomplished by transmitting the ACn command. Transmitting an ACn command is allowed at any time to any receiving LLC provided that the transmitting LLC is not currently awaiting an ACn response PDU from that LLC.

Upon being passed a DL-DATA-ACK.request primitive from the data link user, the LLC shall transmit an ACn command PDU containing the LSDU and with the P bit set to *0*.

Upon being passed a DL-REPLY.request primitive from the data link user, the LLC shall transmit an ACn command PDU containing the LSDU and with the P bit set to *1*.

When an ACn command PDU is constructed the value of V(SI) shall be used to select the LLC control field code of the PDU. When V(SI) is *0* the LLC control field code shall be AC0, and when V(SI) is *1* the LLC control field code shall be AC1.

When the LLC transmits a command PDU, it shall start an acknowledgement timer for that transmission and increment an internal transmission count variable. If no ACn response PDU is received before the acknowledgement timer expires, the transmitting LLC shall retransmit the command, increment the internal transmission count variable, and reset and restart the acknowledgement timer.

If still no response is received the retransmission procedure shall be repeated until the value of the internal transmission count variable is equal the value of the logical link parameter N11, as described in 7.6.3, at which time an unsuccessful status shall be reported to the data link user.

The acknowledgement timer and the internal transmission count shall be maintained separately for each Type 3 information exchange between a pair of transmitting and receiving LLCs.

Type 3 information exchange shall not interfere with any Type 1 operation.

The maximum value for the acknowledgement timer is N13.

The maximum value for the internal transmission count variable is N11.

7.5.4.2.2 Receiving ACN Commands

Upon receipt of an ACn command PDU, the LLC shall compare the V(RI) receive state variable with bit eight of the LLC control field code of the received LPDU (*0* for AC0 or *1* for AC1) from that SAP.

If the comparison shows equality the received PDU is recognised to be a non-duplicate, otherwise the received PDU is recognised to be a duplication of the most recently received ACn command PDU.

7.5.4.2.2.1 Non-duplicate ACN Command

If the received LPDU is valid, not null, the P bit is *0*, the LSDU shall be passed to the data link user in a DL-DATA-ACK.*indication* primitive.

If the P bit is *1* and the requested reply LSDU can be accessed, a DL-REPLY.indication primitive shall be passed to the data link user. If the LSDU is not null, it shall be passed in the *indication primitive*.

If the P bit is *1* and the requested reply LSDU cannot be accessed and the received LSDU was non-null, the received LSDU shall be passed to the data link user in a DL-DATA-ACK.*indication* primitive.

The state variable V(RI) of the SAP associated with the received command PDU shall be set equal to the complement of the C/R bit of the MAC control field in the received PDU.

The state variable V(RB) of the received command PDU shall be set to indicate the success or failure of the reception of the LSDU (if non-null) in the received PDU.

LLC shall acknowledge the receipt of a non-duplicate ACn command PDU by transmitting to the originator of the command an ACn response PDU having bit 8 of the LLC control field set to the (new) value of the V(RI)

If the P bit in the received command PDU is *0*, the response PDU shall be transmitted with the F bit set to *0* and with only a status subfield in the information field.

If the P bit in the command PDU is *1*, the response PDU shall be transmitted with the F bit set to *1*, and with the information field containing the LSDU previously associated with the SAP, if it was available

7.5.4.2.2.2 Duplicate ACN Commands

The LLC-procedures upon the reception of a duplicate ACn command PDU are the same as those for the non-duplicate PDU with the following exceptions.

The V(RI) and V(RB) state variables are not affected by the reception of a duplicate command PDU.

The DL-DATA-ACK.indication primitive is not issued, regardless of the P bit in the command PDU.

If an LSDU is received in the command PDU, it is discarded.

7.5.4.2.3 Transmitting ACN Responses

An AC0 response PDU shall be transmitted only upon the reception of an AC1 command.

An AC1 response PDU shall be transmitted only upon the reception of an AC0 command

The response shall be transmitted to the transmitter of the associated command PDU

The status subfield in the response PDU shall indicate whether or not resources were available to successfully receive the information field in the associated command PDU and, in the case of the F bit equal to *1*, whether or not an LSDU was available for return in the response PDU.

The status code in the CCCC portion of the status subfield of the ACn response PDU is set according to the reception status stored previously in the appropriate V(RB) state variable.

7.5.4.2.4 Receiving Acknowledgement

After transmitting an ACn command PDU to some remote LLC, the transmitting LLC shall expect to receive an acknowledgement in the form of an ACn PDU from the LLC to which the command PDU was transmitted.

AC0 commands shall receive an AC1 acknowledgement and vice versa.

Upon receiving such a response PDU, the LLC shall compare bit eight of the LLC control field code in the response PDU with the current value of the transmit sequence state variable V(SI).

If the comparison shows inequality, the response is considered valid and the LLC shall stop the acknowledgement timer associated with the transmission for which the acknowledgement was received, and reset the internal transmission count to zero. The V(SI) state variable shall be complemented.

The LLC shall pass a DL-DATA-ACK-STATUS.indication primitive or a DL-REPLY-STATUS.indication primitive to the data link user, depending on which request primitive is being confirmed. In the case that response data was returned in the ACn response PDU, the LSDU shall be passed to the data link user.

LLC shall pass the status to the data link user based on the status subfield in the response PDU.

If the comparison of bit eight of the LLC control field code in the response PDU with the current value of the transmit sequence state variable V(SI) shows equality, the ACn response PDU shall be considered invalid. The LLC shall take no further action, and shall continue to expect to receive a valid ACn response PDU. The acknowledgement timer (maximum value is N13) shall not be affected.

7.5.5 List of Logical Data Link Parameters

A number of logical data link parameters are defined, the actual range of values are predefined in the BST on the application layer which is the data link layer user.

7.5.5.1 Maximum Number of Octets in a PDU, N10

N10 is a logical link parameter that denotes the maximum number of octets in a PDU. Refer to the MAC protocol definition for any limitation N10 in a PDU.

7.5.5.2 Minimum Number of Octets in a PDU

A minimum length valid command PDU shall contain the control field. Thus the minimum number of octets in a valid command PDU shall be 1.

A minimum length valid ACn response PDU shall contain the control field and the status subfield in that order. Thus the minimum number of octets in a valid ACn response PDU shall be 2.

7.5.5.3 Maximum Number of Transmissions, N11

N11 is a logical link parameter that indicates the maximum number of times that an ACn command PDU is transmitted by LLC trying to accomplish a successful information exchange. Normally, N11 is set large enough to overcome the loss of a PDU due to link error conditions. The value of N11 may be set to *1* so that LLC does not itself requeue a PDU to the MAC sublayer, but retransmissions may be initiated by the data link layer user.

7.5.5.4 Acknowledgement Time, N13

The acknowledgement time is a logical link parameter that determines the period of the acknowledgement timers, and as such shall define the time interval during which the LLC shall expect to receive an ACn response PDU from a specific LLC from which the LLC is awaiting a response PDU. The acknowledgement time shall take into account any delay introduced by the MAC sublayer and whether the timer is started at the beginning or at the end of the transmitting of the ACn command PDU by the LLC. The proper operation of the procedure shall require that the acknowledgement time shall be greater than the normal time between the transmitting of an ACn command PDU and the reception of the corresponding ACn response PDU.

The unit for the acknowledgement time is defined MAC specific. The public uplink windows allocated are used for this timing purpose. The value may be different for the Fixed Equipment and the Mobile Equipment, and therefore two parameter values are defined N13FE for the Fixed Equipment and N13ME for the Mobile Equipment.

NOTE: The Receive Lifetime and Transmit Lifetime as defined by ISO 8802-2:1989 are set to infinity and therefore not defined here.

7.5.6 Precise Description of Procedures

This subclause contains a precise description of the LLC procedures.

The LLC operation is described using the following three types of components:

a) *Type 1 Component.* This component is responsible for transmitting Type 1 commands upon request of the data link layer user and for processing Type 1 commands as they are received from the MAC sublayer and putting it forward to the data link layer user.

b) *Type 3 Receiver Component.* This component is responsible for processing Type 3 commands as they are received from the MAC sublayer, and for returning Type 3 responses to the originators of the commands.
At a fixed LLC there is a separate Type 3 Receiver Component for each private link address (for each Mobile Equipment in the communication zone).
At mobile LLCs there is only one Type 3 Receiver Component at one time.

c) *Type 3 Sender Component.* This component is responsible for transmitting Type 3 commands upon request of the data link user, and for the processing of Type 3 responses when they are received from the MAC sublayer.
At a fixed LLC there is potentially a separate Type 3 Sender Component for each private link address (for each Mobile Equipment in the communication zone).
At mobile LLCs there is only one Type 3 Sender Component at one time.

The operation of the components is described using a state machine description.

7.5.6.1 Type 1 Component

The Type 1 Component handles all LLC Type 1 PDU traffic for a particular link address in the LLC. An UI PDU is transmitted to one or more (only downlink) remote SAPs in response to an user request, to transmit a service data unit. The Type 1 Component shall process Type 1 LPDUs addressed for a particular link address.

Table 5: Type 1 Component State Transition Table

Current State	Event	Action(s)	Next State
READY	RECEIVE_UI	UNITDATA_INDICATION()	READY
	UNITDATA_REQUEST	TRANSMIT_UI()	READY

Table 5 is showing the Type 1 Component state transition table

7.5.6.1.1 State Description

1) **READY.** This is the only state. SAP is capable of receiving and transmitting Type 1 command PDUs.

7.5.6.1.2 Event Description

1) **RECEIVE_UI.** The MAC sublayer has passed to LLC an *X*-MA-DATA.indication primitive containing an UI command PDU.
2) **UNITDATA_REQUEST.** The data link user has passed a DL-UNITDATA.request primitive to the LLC.

7.5.6.1.3 Action Description

1) **UNITDATA_INDICATION**. Pass to the data link user a DL-UNITDATA.indication primitive containing an LSDU equal to the information field from the associated received command PDU.

2) **TRANSMIT_UI**. Transmit an *X*-MA-DATA.request primitive containing an UI command PDU to the MAC sublayer. At the Fixed Equipment the response request parameter of the DL-UNITDATA.request primitive shall be passed to MAC sublayer via the RR parameter of the F-MA-DATA.request primitive.

7.5.6.2 Type 3 Receiver Component Overview

The Type 3 Receiver Component is responsible for receiving ACn commands from remote LLCs and returning the appropriate ACn response. There is one Type 3 Receiver Component for each private link address associated with received Type 3 command PDUs, and this component has only one state. All state information is contained in state variables. All operations at the responding LLC necessary for the handling of a single transaction are completed at one time interval. Each Receiver Component uses its own V(RI) state variable and V(RB) state variable when checking for a duplicate command PDU and when checking the status of a previous reception.

At a Mobile Equipment there shall be one Receiver Component communicating with Type 3 operation.

At a Fixed Equipment there shall be as many receiver components as Mobile Equipments communicating with Type 3 operation in the communication zone.

Table 6 below shows the Type 3 Receiver Component state transition table

NOTE: This model is more suitable than a multi-state model, because the Type 3 operations are transaction oriented; that is, each command-response pair is essentially independent.

7.5.6.2.1 State Description

READY. LLC is capable of receiving and acknowledging Type 3 PDUs.

7.5.6.2.2 Function Description

The following function return values are used both for qualifying events and for supplying values used in actions.

1) **RECEIVE STATUS( )**. Returns an indication of the success or failure of the processing of the information field of the received command PDU. (It is assumed, however, that the LLC header was successfully received any time an *X*-MA-DATA.indication primitive is passed to LLC.) The possible returned values are:
   - OK Information field successfully processed
   - UN Resources temporarily unavailable for information field.

RS Reception of information is unimplemented or inactivated.
UE Hardware failure prevents information passage to user.
IT Temporary implementation dependent error.
IP Permanent implementation dependent error.

2) **ACCESS( )**. Returns an indication of whether or not an LSDU associated with the remote LLC specified in the received command PDU is available for inclusion in a response PDU. The possible returned values are:
   OK LSDU exists and it can be accessed quickly enough to include it in the response PDU.
   UN Resources temporarily unavailable to access the LSDU.
   RS The return of an LSDU is unimplemented or inactivated..
   NE Response LSDU was never submitted by user.
   UE Hardware failure prevents information passage from user.
   IT Temporary implementation dependent error.
   IP Permanent implementation dependent error.

7.5.6.2.3 Event Description

1) **REPLY_UPDATE_REQUEST**. The data link user has passed a DL-REPLY-UPDATE.request primitive to LLC.

2) **RECEIVE_ACn_CMD(SQC, P, INFO)**. The MAC sublayer has passed to LLC an *X*-MA-DATA.indication primitive containing an AC0 or AC1 command PDU, where the command sequence bit SQC (bit eight of the LLC control field code) is *0* for an AC0 command or *1* for an AC1 command. The following parameter values exist for this event:
   SQC=V(RI) Either the command sequence bit is equal to the V(RI) state variable for this Receiver Component, or that state variable does not exist.
   SQC<>V(RI) There exists a V(RI) state variable for this Receiver Component and the command sequence bit is not equal to that state variable.
   P=*0* The P bit in the command is a *0*.
   P=*1* The P bit in the command is a *1*.
   INFO=NULL The information field in the command is null (of zero length).
   INFO<>NULL The information field in the command is not null.

In the state transition table, some of the events are qualified by the following conditions. The event is recognised only when the condition is true.

3) **RECEIVE_STATUS( )=OK**. The information field in the received command PDU was successfully received and can be passed to the user.

4) **RECEIVE_STATUS( )<>OK**. The information field in the received command PDU was not successfully received or cannot be passed to the user.

5) **ACCESS( )=OK**. A response LSDU associated with the SAP does exist and it can be accessed quickly enough to include it in the response PDU.

6) **ACCESS( )<>OK**. Either a response LSDU associated with the SAP does not exist or the LSDU does exist but it cannot be accessed quickly enough to include it in the response PDU.

Table 6: Type 3 Receiver Component State Transition Table

Current State	Event	Action(s)	Next State
READY	REPLY_UPDATE_REQUEST	SAVE:=GIVEN_LSDU REPLY_UPDATE_STATUS_INDICATION	READY
	RECEIVE_ACn_CMD(SQC=V(RI), P=*0* INFO<>NULL) and RECEIVE_STATUS( )=OK	TRANSMIT_ACn_RSP(SQR=*1*-SQC, F=*0*, C=OK, R=NR, LSDU=NULL) DATA_ACK_INDICATION V(RI):=*1*-SQC V(RB):=OK	READY
	RECEIVE_ACn_CMD(SQC=V(RI), P=*0* INFO=NULL) and RECEIVE_STATUS( )=OK	TRANSMIT_ACn_RSP(SQR=*1*-SQC, F=*0*, C=OK, R=NR, LSDU=NULL) V(RI):=*1*-SQC V(RB):=OK	READY
	RECEIVE_ACn_CMD(SQC=V(RI), P=*0*) and RECEIVE_STATUS( )<>OK	TRANSMIT_ACn_RSP(SQR=*1*-SQC, F=*0*, C=RECEIVE_STATUS( ), R=NR, LSDU=NULL) V(RI):=*1*-SQC V(RB):= RECEIVE_STATUS( )	READY
	RECEIVE_ACn_CMD(SQC=V(RI), P=*1*) and RECEIVE_STATUS( )=OK and ACCESS( )=OK	TRANSMIT_ACn_RSP(SQR=*1*-SQC, F=*1*, C=OK, R=OK, LSDU=SAVE) REPLY_INDICATION(LSDU=INFO) V(RI):=*1*-SQC V(RB):=OK	READY
	RECEIVE_ACn_CMD(SQC=V(RI), P=*1*) and RECEIVE_STATUS( )<>OK and ACCESS( )=OK	TRANSMIT_ACn_RSP(SQR=*1*-SQC, F=*1*, C= RECEIVE_STATUS( ), R=OK, LSDU=SAVE) REPLY_INDICATION(LSDU=NULL) V(RI):=*1*-SQC V(RB):= RECEIVE_STATUS( )	READY
	RECEIVE_ACn_CMD(SQC=V(RI), P=*1*, INFO<>NULL) and RECEIVE_STATUS( )=OK and ACCESS( )<>OK	TRANSMIT_ACn_RSP(SQR=*1*-SQC, F=*1*, C=OK, R=ACCESS( ), LSDU=NULL) DATA_ACK_INDICATION V(RI):=*1*-SQC V(RB)=OK	READY
	RECEIVE_ACn_CMD(SQC=V(RI), P=*1*, INFO=NULL) and RECEIVE_STATUS( )=OK and ACCESS( )<>OK	TRANSMIT_ACn_RSP(SQR=*1*-SQC, F=*1*, C=OK, R=ACCESS( ), LSDU=NULL) V(RI):=*1*-SQC V(RB)=OK	READY
	RECEIVE_ACn_CMD(SQC=V(RI), P=*1*) and RECEIVE_STATUS( )<>OK and ACCESS( )<>OK	TRANSMIT_ACn_RSP(SQR=*1*-SQC, F=*1*, C=RECEIVE_STATUS( ), R=ACCESS( ), LSDU=NULL) V(RI):=*1*-SQC V(RB):= RECEIVE_STATUS( )	READY
	RECEIVE_ACn_CMD(SQC<>V(RI), P=*0*)	TRANSMIT_ACn_RSP(SQR=*1*-SQC, F=*0*, C=V(RB), R=NR, LSDU=NULL)	READY
	RECEIVE_ACn_CMD(SQC<>V(RI), P=*1*) and ACCESS( )=OK	TRANSMIT_ACn_RSP(SQR=*1*-SQC, F=*1*, C=V(RB), R=NR, LSDU=SAVE) REPLY_INDICATION(LSDU=NULL)	READY
	RECEIVE_ACn_CMD(SQC<>V(RI), P=*1*) and ACCESS( )<>OK	TRANSMIT_ACn_RSP(SQR=*1*-SQC, F=*1*, C=V(RB), R=ACCESS( ), LSDU=NULL)	READY

7.5.6.2.4 Action Description

1) **SAVE:=GIVEN_LSDU**. The LSDU given in the associated DL-REPLY-UPDATE.request primitive is held in readiness for transmission be being placed in the abstract location, SAVE. The SAVE location used is specifically associated with the SAP given in the primitive and the new LSDU replaces any previously held for that SAP.

2) **TRANSMIT_ACn_RSP(SQR, F, C, R, LSDU)**. Pass an *X*-MA-DATA.request primitive to the MAC sublayer containing an AC0 or AC1 response PDU. The following parameter values exist for this action:

   SQR=*1*-SQC The response sequence bit (bit eight of the LLC control field code) is set to the complement of the sequence bit from the received command

   F=*0* The F bit of the response is set to *0*.

   F=*1* The F bit of the response is set to *1*.

   C=OK The CCCC portion of the status subfield is set to the "OK" code (successful reception).

   C=RECEIVE_STATUS( ) The CCCC portion of the status subfield is set to the value returned by the RECEIVE_STATUS function.

   C=V(RB) The CCCC portion of the status subfield is set equal to the V(RB) state variable associated with the link address of the received command PDU.

   R=NR The RRRR portion of the status subfield is set to the "NR" code (response data not requested).

   R=OK The RRRR portion of the status subfield is set to the "OK" code (response data included).

   R=ACCESS( ) The RRRR portion of the status subfield is set to the value returned from the ACCESS function.

   LSDU=NULL The LSDU subfield of the response is null (of zero length).

   LSDU=SAVE The LSDU subfield of the response contains the LSDU held in readiness in the SAVE location for this SAP.

NOTE: At the Fixed Equipment the medium for the response of the Mobile Equipment shall allocated in immediate connection to the ACn-Command.

3) **DATA_ACK_INDICATION.** Pass to the data link user a DL-DATA-ACK.indication primitive containing an LSDU equal to the information field from the associated received command PDU.

4) **REPLY_INDICATION(LSDU)**. Pass to the data link user a DL-REPLY.indication primitive. The following parameter values exist for this action

   LSDU=INFO The user is passed an LSDU equal to the information field from the associated received command PDU. This field may be null.)

   LSDU=NULL The user is passed a null LSDU

5) **REPLY_UPDATE_STATUS_INDICATION**. Pass to the data link user a DL-REPLY-UPDATE-STATUS.indication primitive.

6) **V(RI):=*1*-SQC**. The V(RI) state variable for this Receiver Component is set to the complement of the sequence bit (bit eight of the LLC control field code) in the received command PDU.

7) **V(RB):=OK**. The V(RB) state variable for this Receiver Component is set to the "OK" code (successful reception).

8) **V(RB):=RECEIVE_STATUS( )**. The V(RB) state variable for this Receiver Component is set to the value returned by the RECEIVE_STATUS function.

7.5.6.3 Type 3 Sender Component

The Type 3 Sender Component is responsible for transmitting ACn command PDUs to a remote LLC. The Sender Component also receives response PDUs and retransmits the command PDUs if no response is received. The Type 3 protocol allows one outstanding (not yet acknowledged) command PDU for each private SAP. Each Sender Component uses its own V(SI) state variable when selecting the LLC control field code for a new transmission and when checking for a valid response LLC control field code.

There shall be one Sender Component at each Mobile Equipment, communicating with Type 3 operation.

There shall be as many receivers components as Mobile Equipments, communicating with Type 3 operation, in the communication zone.

Each Sender Component has three states. In the IDLE state, it is capable of processing a request from the data link user to transmit a new command PDU. In the WAIT_A and WAIT_R states, the component is only capable of receiving a response from the remote LLC, or of timing out and performing a retransmission. The WAIT_A state is used when the expected response is a data-less acknowledgement, and the WAIT_R state is used when the expected response is a data-bearing reply.

Table 7 is showing the Type 3 Sender Component state transition table

7.5.6.3.1 State Description

1) **IDLE**. In this state, LLC is capable of executing a request from the data link user to transmit a Type 3 command PDU.
2) **WAIT_A**. In this state, LLC is waiting for an acknowledgement of a previously transmitted Type 3 command PDU which was invoked by a DL-DATA-ACK.request primitive.
3) **WAIT_R**. In this state, LLC is waiting for an acknowledgement of a previously transmitted Type 3 command PDU which was invoked by a DL-REPLY.request primitive.

Table 7: Type 3 Sender Component State Transition Table (continued)

Current State	Event	Action(s)	Next State
IDLE	RECEIVE_ACn_RSP	(No action)	IDLE
	DATA_ACK_REQUEST	TRANSMIT_ACn_CMD(SQC=V(SI), P=*0*) START_ACK_TIMER RETRY_COUNT:=RETRY_COUNT+*1*	WAIT_A
	REPLY_REQUEST	TRANSMIT_ACn_CMD(SQC=V(SI),P=*1*) START_ACK_TIMER RETRY_COUNT:=RETRY_COUNT+*1*	WAIT_R
WAIT_A	RECEIVE_ACn_RSP(SQR<>V(SI), LSDU=NULL)	DATA_ACK_STATUS_INDICATION (STATUS=STATUS_SUBFIELD) CANCEL_ACK_TIMER RETRY_COUNT:=*0* *V(SI):=1-V(SI)*	IDLE
	RECEIVE_ACn_RSP(SQR<>V(SI), LSDU<>NULL)	DATA_ACK_STATUS_INDICATION(STATUS=PE) CANCEL_ACK_TIMER RETRY_COUNT:=*0* V(SI):=*1*-V(SI) REPORT_STATUS(ILLEGAL_LSDU)	IDLE
	RECEIVE_ACn_RSP(SQR=V(SI))	(no action)	WAIT_A
	ACK_TIMER_EXPIRED and RETRY_COUNT<N11	RETRANSMIT_OLD_CMD START_ACK_TIMER RETRY_COUNT:=RETRY_COUNT+*1*	WAIT_A
	ACK_TIMER_EXPIRED and RETRY_COUNT>=N11	DATA_ACK_STATUS_INDICATION (STATUS=UNSUCCESSFUL) RETRY_COUNT:=*0*	IDLE
WAIT_R	RECEIVE_ACn_RSP(SQR<>V(SI), R=OK)	REPLY_STATUS_INDICATION (STATUS=STATUS_SUBFIELD, LSDU=GIVEN_LSDU) CANCEL_ACK_TIMER RETRY_COUNT:=*0* V(SI):=*1*-V(SI)	IDLE
	RECEIVE_ACn_RSP(SQR<>V(SI), R<>OK)	REPLY_STATUS_INDICATION (STATUS=STATUS_SUBFIELD, LSDU=NULL) CANCEL_ACK_TIMER RETRY_COUNT:=*0* V(SI):=*1*-V(SI)	IDLE

Table 7: Type 3 Sender Component State Transition Table (concluded)

Current State	Event	Action(s)	Next State
WAIT_R	RECEIVE_ACn_RSP(SQR<>V(SI))	(No action)	WAIT_R
	ACK_TIMER_EXPIRED and RETRY_COUNT<N11	RETRANSMIT_OLD_CMD START_ACK_TIMER RETRY_COUNT:=RETRY_COUNT+1	WAIT_R
	ACK_TIMER_EXPIRED and RETRY_COUNT>=N11	DATA_ACK_STATUS_INDICATION (STATUS=UNSUCCESSFUL, LSDU=NULL) RETRY_COUNT:=0	IDLE

7.5.6.3.2 Event Description

1) **DATA_ACK_REQUEST**. The data link user has passed a DL-DATA-ACK.request primitive to the LLC.

2) **REPLY_REQUEST**. The data link user has passed a DL-REPLY.request primitive to the LLC.

3) **RECEIVE_ACn_RSP(SQR, R, LSDU)**. The MAC sublayer has passed to LLC an *X*-MA-DATA.indication primitive containing an AC0 or AC1 response PDU, where the response sequence bit SQR (bit eight of the LLC control field code) is *0* for an AC0 response or *1* for an AC1 response. The following parameter values exist for this event:

   SQR=V(SI) The response sequence bit is equal to the V(SI) state variable for this Sender Component.

   SQR<>V(SI) The response sequence bit is not equal to the V(SI) state variable for this Sender Component.

   R=OK The RRRR portion of the status subfield of the received response PDU shows the "OK" status (indicating that an LSDU is included).

   R<>OK The RRRR portion of the status subfield of the received response PDU shows a status other than "OK" (indicating that an LSDU is not included).

   LSDU=NULL The LSDU subfield in the response is null (of zero length).

   LSDU<>NULL The LSDU subfield in the response is not null.

4) **ACK_TIMER_EXPIRED**. The acknowledgement timer associated with this Sender Component (i.e., the timer for a specific private link address) has expired.

In the state transmission table, some of the events are qualified by the following conditions. The event is recognised only when the condition is true.

5) **RETRY_COUNT<N11**. The retry count for this Sender Component is less than the logical link parameter N11.

6) **RETRY_COUNT>=N11**. The retry count for this Sender Component is greater than or equal to the logical link parameter N11.

7.5.6.3.3 Action Description

1) **TRANSMIT_ACn_CMD(SQC, P)**. Pass an *X*-MA-DATA.request primitive containing an AC0 or AC1 command PDU to the MAC sublayer. The following parameter values exist for this action:

SQC=V(SI). Set the command sequence bit (bit eight of the LLC control field code) equal to the V(SI) state variable for this Sender Component. If that V(SI) state variable does not exist, create it with a value of zero; otherwise use the current value.

P=*0*. The P bit of the response is set to *0*.

P=*1*. The P bit of the response is set to *1*.

At the Fixed Equipment the RR (response request) parameter of the F-MA-DATA.request primitive shall be set.

2) **RETRANSMIT_OLD_CMD**. Pass an *X*-MA-DATA.request primitive containing the ACn command PDU most recently transmitted by this Sender Component to the MAC sublayer. At the Fixed Equipment the RR, response request, parameter of the F-MA-DATA.request primitive shall be set.

3) **START_ACK_TIMER**. Start the acknowledgement timer for this Sender Component.

4) **CANCEL_ACK_TIMER**. Cancel the acknowledgement timer for this Sender Component.

5) **DATA_ACK_STATUS_INDICATION(STATUS)**. Pass to the data link user a DL-DATA-ACK-STATUS.indication primitive. The following parameter values exist for this action:

   STATUS=UNSUCCESSFUL. The status parameter is set to indicate failure to receive an acknowledgement.

   STATUS=STATUS_SUBFIELD. The status parameter is set according to the status returned in the received response PDU.

6) **REPLY_STATUS_INDICATION(STATUS, LSDU)**. Pass to the data link user a DL-REPLY-STATUS.indication primitive. The following parameter values exist for this action:

   STATUS=UNSUCCESSFUL. The status parameter is set to indicate failure to receive an acknowledgement.

   STATUS=STATUS_SUBFIELD. The status parameter is set according to the status returned in the received response PDU.

   STATUS=PE. The status parameter is set to the PE status (protocol error).

   LSDU=NULL. The data parameter is null.

   LSDU=GIVEN_LSDU. The data parameter contains the LSDU given in the associated *X*-MA-DATA.indication primitive.

7) **V(SI):=*1*-V(SI)**. Complement the V(SI) state variable for this Sender Component.

8) **RETRY_COUNT:=*0***. Set the retry counter for this Sender Component to *0*.

9) **RETRY_COUNT:=RETRY_COUNT+*1***. Increment the retry counter for this Sender Component.

10) **REPORT_STATUS(ILLEGAL_LSDU)**. Report to layer management that an LSDU was received in violation of the Type 3 LLC protocol.

ANNEX (Informative)

ANNEX A Interlayer Management

To perform the management within each layer and for the inter-layer management, relevant parameters have to be exchanged.

The Beacon Service Table holds all information necessary in order to communicate properly with the Fixed Equipment.

Furthermore information from other layers needed by the Layer 2 as well as information from Layer 2 has to be made available to other layers.

The next paragraphs describes the layer 2 parameters.

ANNEX A.1 Elements of Beacon Service Table

In this section, several elements are discussed as if they are to be included explicitly in the BST. At a certain level of abstraction, this is correct: the values listed below must be known, or otherwise must be made known to the Mobile Equipments as they pass an Fixed Equipment communication zone. However, there are several decisions on actual encoding that depend crucially on the range of values. In particular, if the decision is taken to fix a parameter at one single value, and to exclude any modifications in future systems, then the actual information content of this "parameter" becomes zero, and inclusion in the BST is pointless.

Some protocol "parameter" values are not really set-able since they depend on the physical properties of the communications medium and the implementation. For instance: link turn around times, guard time. Some of these are to be included in the BST nevertheless to enable the vehicle to judge if communication with the beacon is possible.

- N1, number of octets for private link address
  Range: greater or equal to *2*
- N2, maximum number of octets in frame in downlink window

NOTE: *The reason why N2 should be made known to the Mobile Equipment is buffer allocation. On the other hand, this decision is implementation dependent, since an Mobile Equipment may know the maximum frame size for its application; note that the protocol handling does not depend on full buffering of the frame, provided the headers and flags can be interpreted (the FCS can be accumulated without storing the data). Therefore the application layer will have to take the decision.*

- N3, maximum number of octets in frame in private uplink window (including FCS, Flags; excluding Zero Bit Insertion)
  Range: greater or equal to *20*
- N4, maximum number of octets in frame in public uplink window (including FCS, Flags; excluding Zero Bit Insertion)
  Range: greater or equal to *5* + N1
- N5, number of simultaneously allocated consecutive public uplink
  Range: greater or equal to *1*
- N8, maximum number of random delay counter
  Range: greater or equal to 1 (1 is only meaningful in single lane environments)
- N9, maximum value of private uplink window allocation counter
  Range: greater or equal to *5* + N1

- N10, maximum number of octets in an LPDU
  Value: (N2|N3|N4) - (1|N1) - sizeof(MAC + LLC Control Field + FCS + Flag)
- N11, maximum number of transmissions
  Range: greater or equal to 1 (1 means that retransmissions are done by the LLC user layer)
- N12, maximum private medium response time
  Range: greater or than equal to 1 public uplink windows allocated
- N13, acknowledgement time, if not indicated N13FE and N13ME is meant
- N13FE, acknowledgement time of Fixed Equipment
  Range: greater than 1ms
- N13ME, acknowledgement time of Mobile Equipment
  Range: greater or equal to 1 public uplink windows allocated

NOTE: Not all layer 2 parameters (e.g. N6 and N7) are to be included in the BST.

- T1, minimum uplink to downlink turn around time
  Value: dependent on the capabilities of the Mobile Equipment and Fixed Equipment hard- and software
  Range: from 10µs - 1ms
- T2, minimum downlink to downlink window time
  Value: dependent on the capabilities of the Mobile Equipment and Fixed Equipment hard- and software
  Range: from 10µs - 1ms
- T3, downlink to uplink turn around time
  Value: dependent on the capabilities of the Mobile Equipment and Fixed Equipment hard- and software
  Range: from 10µs - 1ms
- T4a, maximum time before start of transmission in a private uplink window (MAC)
  Value: dependent on the capabilities of the Mobile Equipment and Fixed Equipment hard- and software
  Range: from 10µs - 100µs (0.1 ms)
- T4b, maximum time before start of transmission in a public uplink window (MAC)
  Value: dependent on the capabilities of the Mobile Equipment and Fixed Equipment hard- and software
  Range: from 10µs - 1 ms
- T5, duration in time of public uplink window
  Value: dependent on the capabilities of the Mobile Equipment and Fixed Equipment hard- and software
  Range: from 10µs - 50ms (see N5 which is dependent on T5)

NOTE: Depending on the specifications in the ITR 278/9/#74 "DSRC Profiles for RTTI Applications" the parameter ranges indicated above might need to be modified:

ANNEX B Link Layer Control

ANNEX B.1 LAYER 2 Link Overhead

Table B.1: Layer 2 Link Overhead

	pure MAC frame		frame containing UI command PDU		ACn	ACn
	broadcast address	private address	broadcast address	private address	command	response
Framing (Flag / FCS)	4	4	4	4	4	4
Link Address Field	1	4	1	4	4	4
MAC Control Field	1	1	1	1	1	1
LLC Control Field	-	-	1	1	1	2
Status Subfield	-	-	-	-	-	2
Layer 2 overhead	6	9	7	10	10	11

all numbers are indicating the overhead in octets

assumptions: 4 octet length of private address,
zero bit insertion is excluded

ANNEX C Address Establishment

This annex deals with an example of how a communications session between a fixed equipment and a mobile equipment unit could be set up and initialised.

The basic underlying assumptions are that the fixed side periodically broadcasts a beacon service table, BST, containing information on communication parameters, communication profiles and available applications. The BST is transmitted as unnumbered information, UI, with the broadcast address. The frame containing the BST also contains an uplink window allocation, and, since the address is broadcast, it is a public uplink window allocation. The number of consecutive public uplink windows is indicated in the BST. The frame containing the BST is the only broadcast frame allocating uplink window.

The mobile unit waits, sleeping, until, after being waked up, it hears the BST.

The BST is addressed to the data link user, the application layer, and it is interpreted there.

The first action in the application layer is to generate a new link address if the interpretation of the BST indicates that the mobile has arrived at a new beacon. The next action is to read or generate a vehicle service table, VST, containing information on communication parameters, communication profiles and available applications in the mobile.

As an example, let us assume that the BST contains, among other, the information that:

1. the randomly generated link address shall be four octets and
2. each public window allocation allocates three consecutive public uplink windows
3. the maximum random delay counter is three
4. each public uplink window is allowed to contain frames of nine octets maximum
5. the first window starts at 50 µs and each window is 400 µs
6. the mobile must start to transmit no later than 20 µs into each window
7. the maximum private uplink window allocation timer is 1

After receiving the BST, the mobile now interprets it, generates (or recalls) a new address and issues a DL-UNITDATA.request containing the VST.

The interpretation of the BST has also provided the mobile interlayer management with the necessary information on number of, and length of, public uplink windows etc.

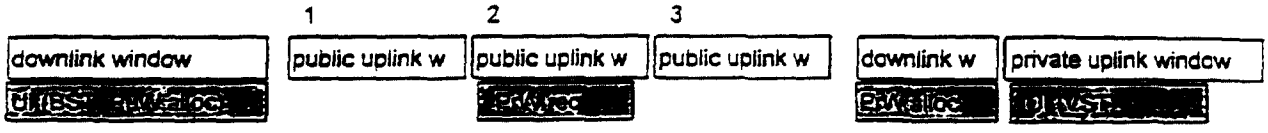
The LLC sublayer discards any state information relating to the earlier SAP and creates a new SAP with the new link address and new state information. The LLC sublayer then issues an MA-DATA.request containing the VST to the MAC sublayer.

The MAC sublayer constructs the frame containing the VST, realises that the frame is too long for the public uplink window that is available and constructs a request for private window using the new link address. It then selects a public uplink window according to the random delay counter and transmits the request for private window is in one public uplink window.

The fixed equipment MAC responds to the request for private window by allocating a private uplink window to the mobile with the indicated link address. In that private uplink window the mobile transmits the pending frame containing the VST.

When the frame is correctly received in the fixed MAC the result will be an MA-DATA.indication to the fixed LLC. The fixed LLC will study the link address and find that it is new, create a new SAP for that link address and issue a DL-UNITDATA.indication.

The sequence of frames/windows can be depicted as in fig A1.



Nm5, number of simultaneously allocated public uplink windows = 3

Nm6, random delay counter, = 2

Nm7, maximum random delay counter, = 3

Fig C1 BST - VST exchange for newly arrived mobile equipment, windows

The sequence of service primitives and frames can also be depicted as in fig A2

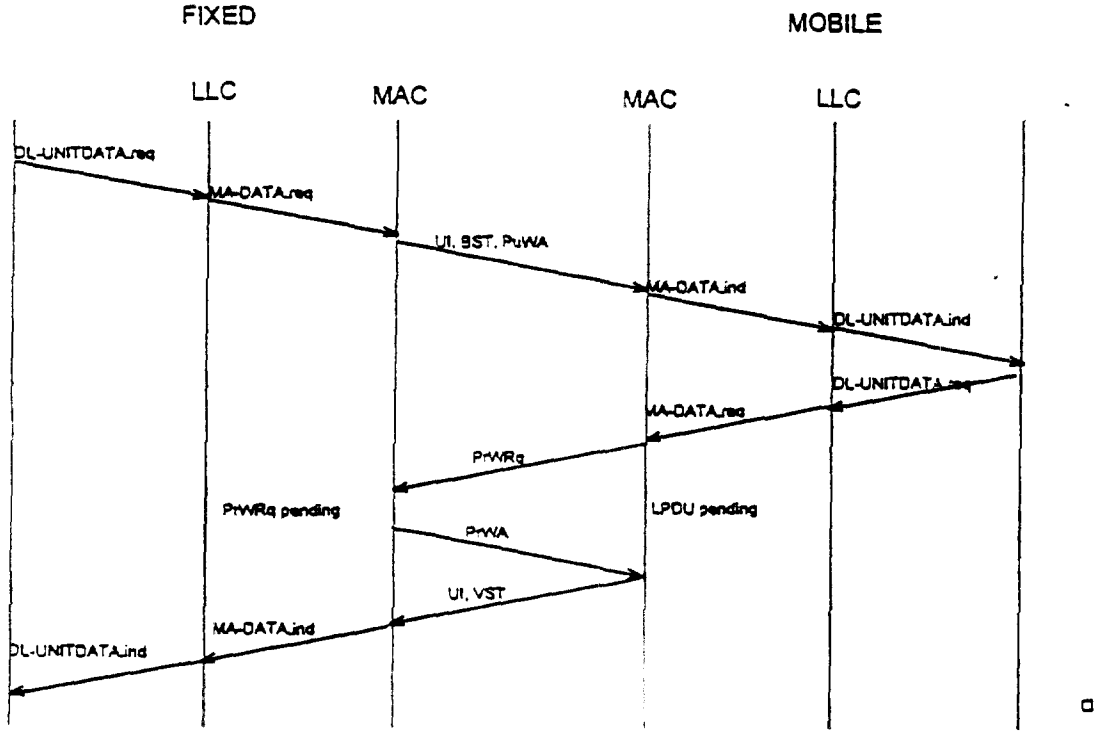
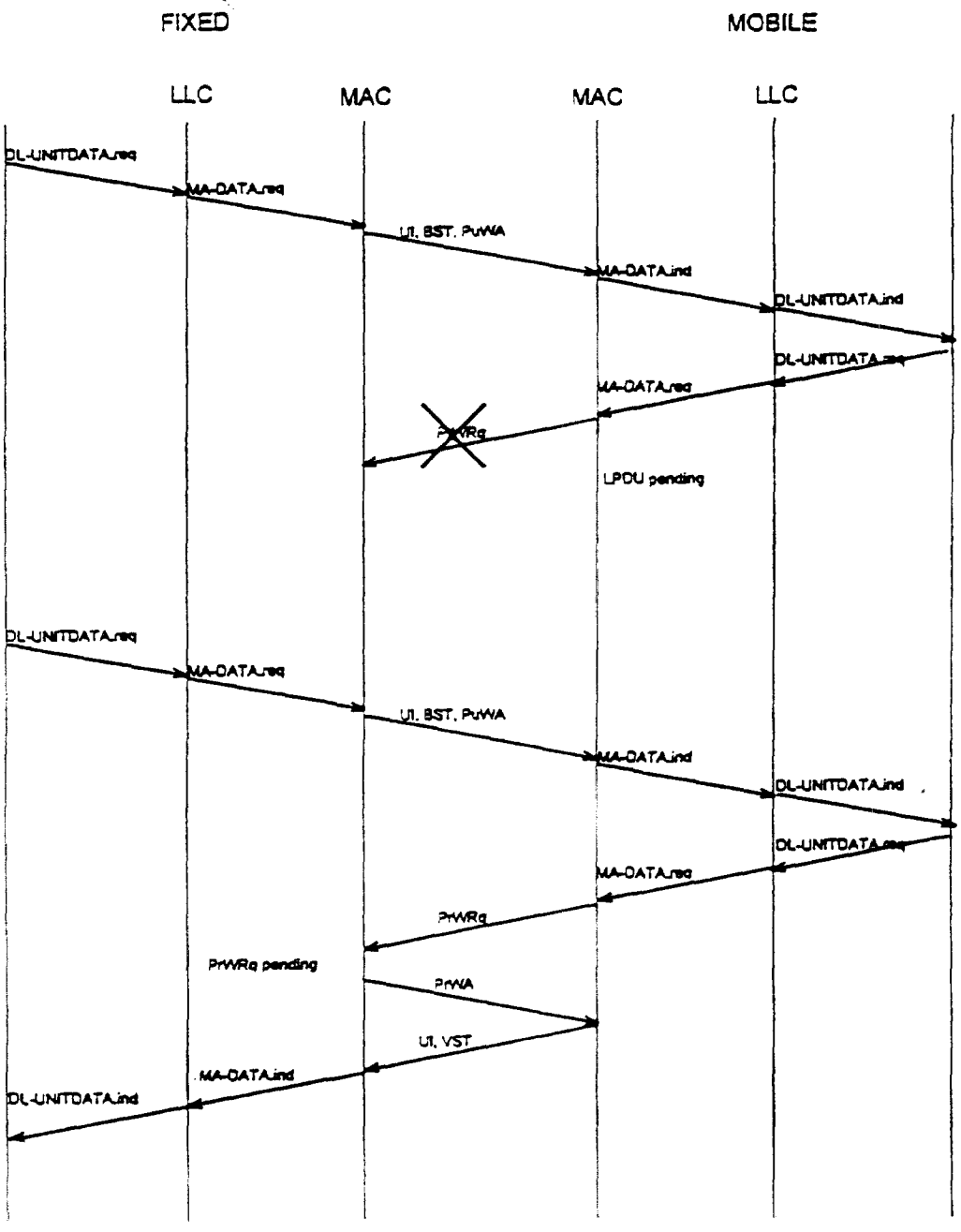


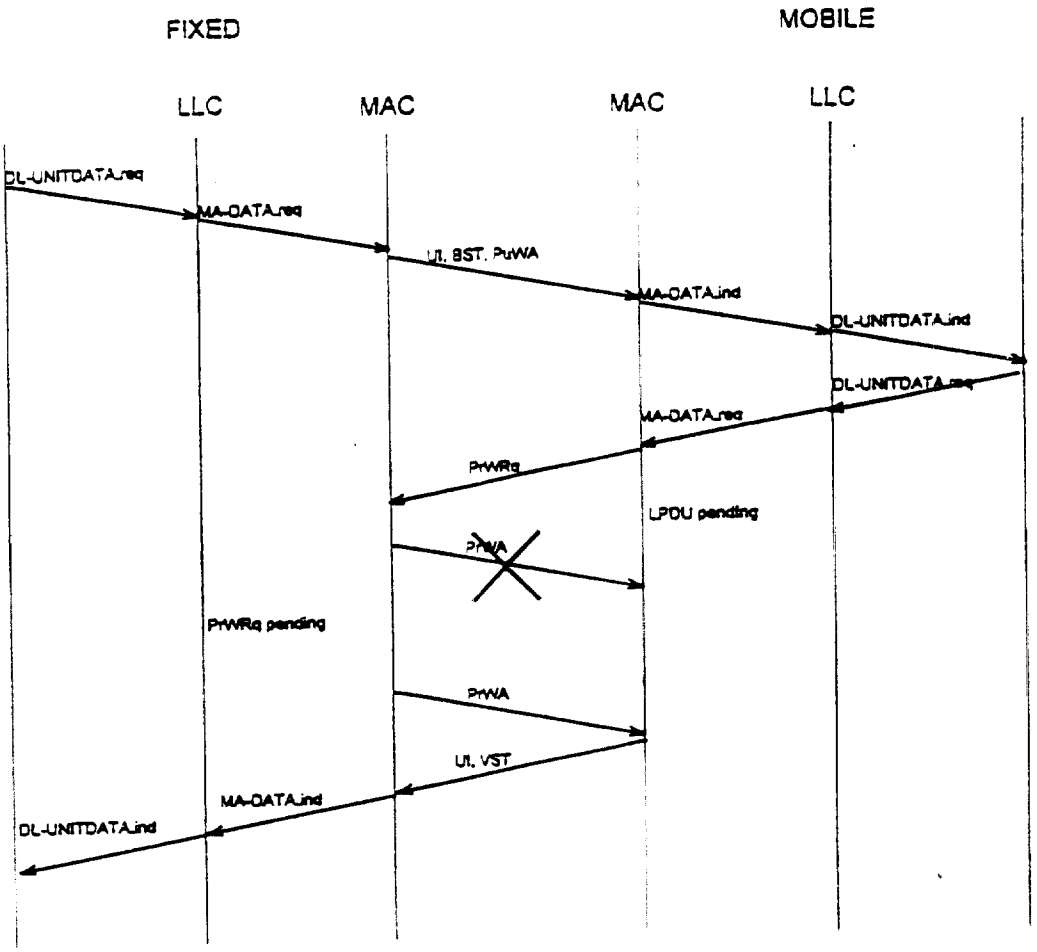
Fig C2 BST - VST exchange for newly arrived mobile equipment, primitives

In any DSRC communication the unreliability of the link must be taken into account. It is therefore necessary to investigate the possibilities to recover from loss of frames also in the early phases of communication:

If the frame transmitted on the uplink in the public uplink window is lost (due to contention or for other reasons) the mobile equipment will not know until the private uplink window allocation timer has expired. Since, in this example, the maximum value of the timer is 1, the mobile will expect a private window allocation before the next public window allocation, which occurs at the next transmission of the BST.



If the frame transmitted on the downlink allocating the private uplink window is lost, the mobile will not transmit in the private window allocated and the fixed side can reallocate the private uplink window to increase the probability of getting the data



If the UI frame containing the VST, transmitted on the uplink is lost, the fixed side will not receive a valid frame in the private window allocated and it can then reallocate the private uplink window.

APPENDIX E:
Application Layer

ISO/TC 204 Secretariat
Transport Information and Control Systems

ISO/TC 204 N363
November 16, 1997

TITLE:

NP 15628 (ENV 12834) - Road Transport and Traffic Telematics (RTTT) - Dedicated Short Range Communication (DSRC) - Application Layer

SOURCE:

ISO/TC204/WG15

REQUESTED ACTION:

For CD Comment

Although official date for reply is February 17th, please reply by February 1st (if possible) as WG 15 is working to resolve comments.

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